Graphic courtesy of Extemin

Lean Construction

What is this thing called “LEAN”?

“What has changed Manufacturing, and sharply pushed up productivity, are new concepts. Information and automation are less important than new theories of manufacturing, which are an advance comparable to the arrival of mass production 80 years ago.”

Peter Drucker, “The Economist”, pg 12, November 3, 2001

Construction Weekly Work Plan

1 WEEK PLAN

PROJECT: Pilot **FOREMAN: PHILLIP**

ACTIVITY **DATE: 9/20/96**

	Est	Act	Mon	Tu	Wed	Thurs	Fri	Sat	Sun	PPC	REASON FOR VARIANCES
Gas/F.O. hangers O/H "K" (48 hangers)			xxxx Sylvano, Modesto, Terry	xxxx						No	Owner stopped work (changing elevations)
Gas/F.O. risers to O/H "K" (3 risers)					xxxx Sylvano, Mdesto, Terry	xxxx	xxxx	xxxx		No	Same as above-worked on backlog & boiler blowdown
36" cond water "K" 42' 2-45 deg 1-90 deg			xxxx Charlie, Rick, Ben	xxxx	xxxx					Yes	
Chiller risers (2 chillers wk.)						xxxx Charlie, Rick, Ben	xxxx	xxxx		No	Matl from shop rcvd late Thurs. Grooved couplings shipped late.
Hang H/W O/H "J " (240'-14")			xxxx Mark M., Mike	xxxx	xxxx	xxxx	xxxx	xxxx		Yes	
Cooling Tower 10" tie-ins (steel) (2 towers per day)			xxxx Steve, Chris, Mark W.	xxxx	xxxx	xxxx	xxxx	xxxx		Yes	
Weld out CHW pump headers "J " mezz. (18)			xxxx Luke	xxxx	xxxx	xxxx	xxxx	xxxx		Yes	
Weld out cooling towers (12 towers)			xxxx Jeff	xxxx	xxxx	xxxx	xxxx	xxxx		No	Eye injury. Lost 2 days welding time
F.R.P. tie-in to E.T. (9 towers) 50%			xxxx Firt, Packy, Tom	xxxx	xxxx	xxxx	xxxx	xxxx		Yes	
WORKABLE BACKLOG Boiler blowdown-gas vents -rupture disks											

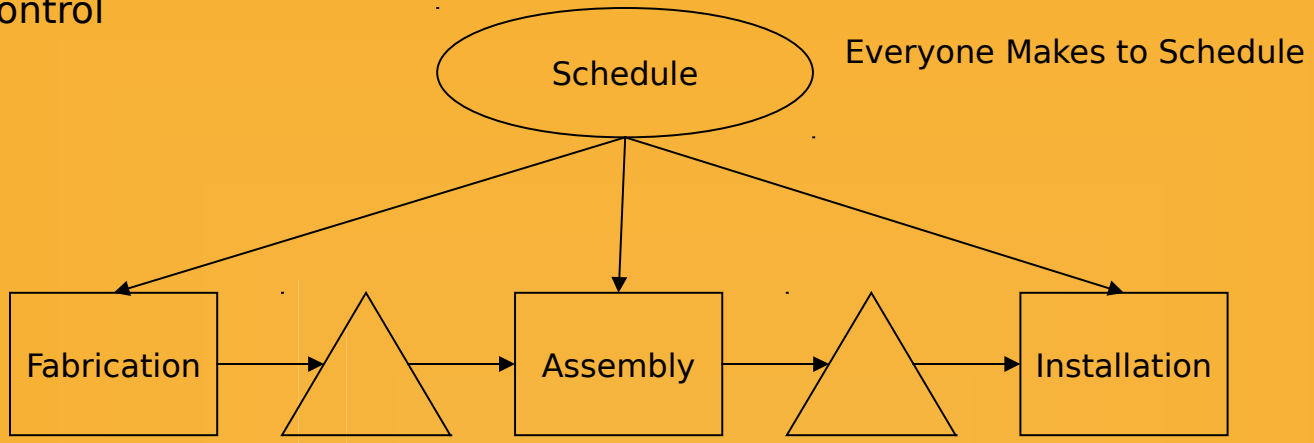
Percent Plan Complete (PPC) = 54%

Production Systems in Construction

- The physical characteristics of production tend to be ignored.
- Production is largely an uncontrolled process.
- Variability in production systems is not taken into account.
- Lack of technical knowledge about production; e.g., reliability of work flow, defect rates, design of processes and operations.
- No systematic process for learning from experience.
- Extreme fragmention, even within a single company.
- Central control fantasy/push system

‘Pushing’ versus ‘Pulling’

Push Control



The longer and the more detailed the forecast the more inaccurate it becomes

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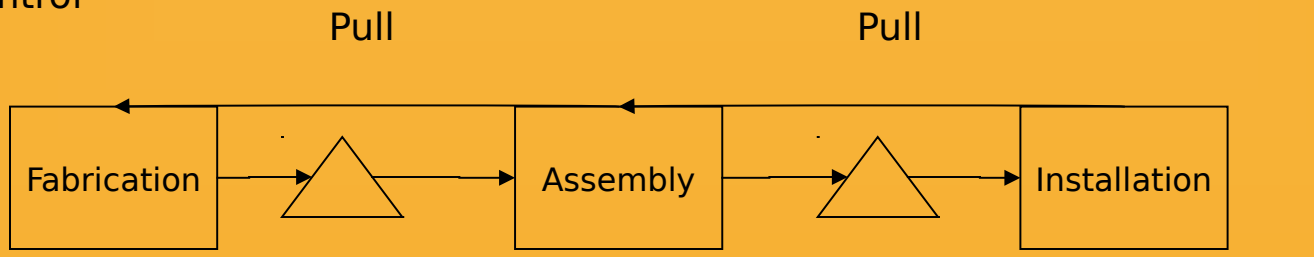
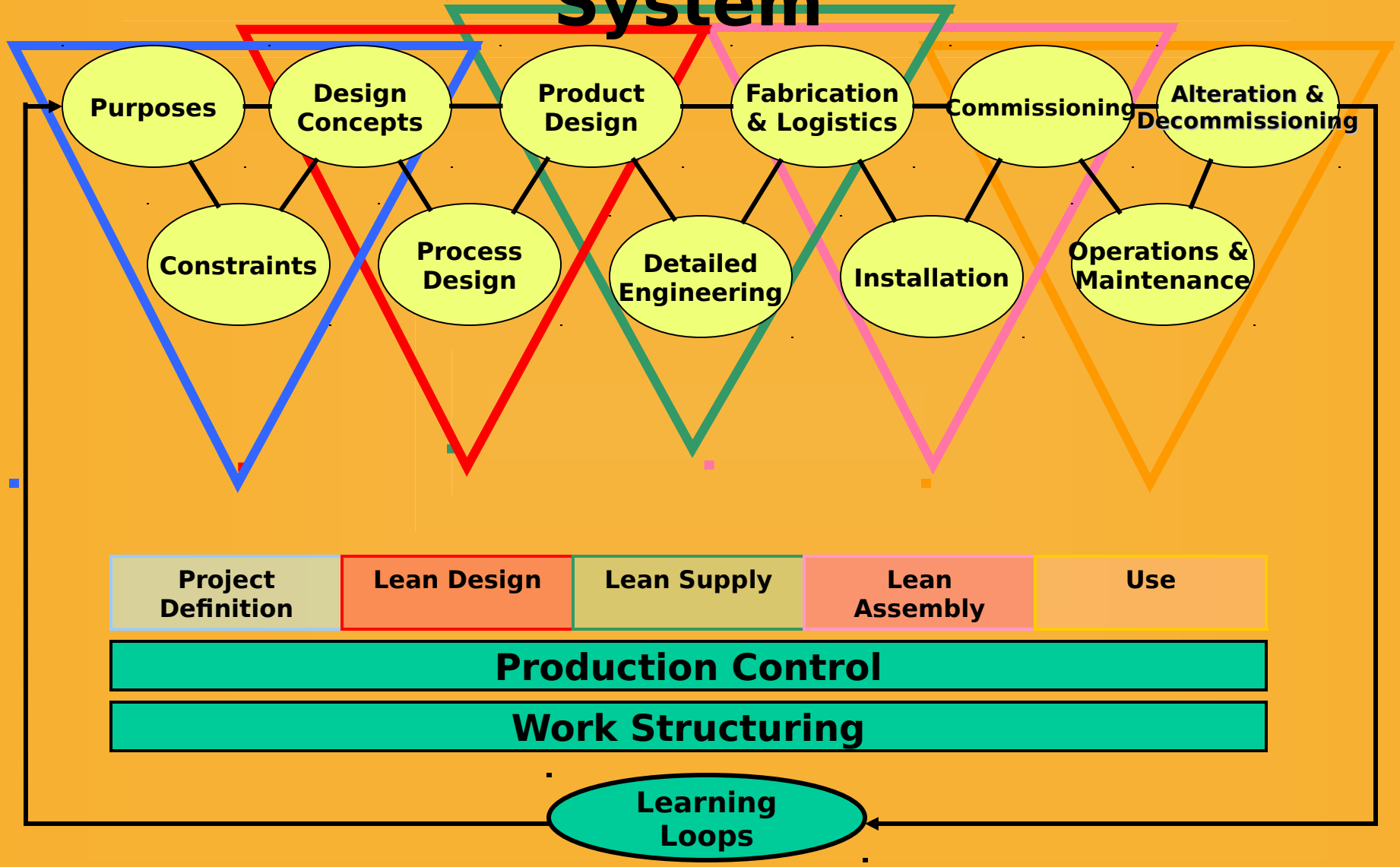
Pull Control



Lean Project Delivery System



Concrete

Terminal 5

Steely resolve

Over the next two years more than 1M.m³ of concrete will be needed on the massive Heathrow Terminal 5 project. Dave Parker reports on a construction revolution that will make sure it is poured on time.

Everyone knows how reinforcement for concrete is procured. First, the structural engineer designs the bridge, or tunnel, or structural frame, then detailed reinforcement drawings are produced and bar bending schedules taken off.

The schedules are sent to a specialist rebar producer, which takes steel bars in a wide range of diameters from its stock bay, cuts them to length, and transforms them into the hundreds of items of reinforcement needed for the project. As these come off the production line they go to a storage yard until transport is available, then off they go to site, where the contractor stores them until the steelfixers are ready to go.

This is not how it happens on the £3.7bn Heathrow Terminal 5 project. Here reinforcement is designed only when the Laing O'Rourke team on site signals it has a pour planned and four days later the steel for the pour, and only the steel for that pour, turns up on time at the right place. Fixing it is easy, because almost all of it is preassembled. Pours that would normally take four days for steel fixing take only one.

Achieving this productivity demanded a massive early investment – for which the T5 team had very good reasons.

"It's a 250ha site with 36 work areas, four batching plants and 28 tower cranes," says T5 demand fulfilment team leader Nigel Harper. "Currently we're pouring up 2,500m³ of concrete a day, say 13,000m³ a week, mainly into heavily reinforced slabs and walls. Yet in all those 250ha there is virtually no storage area.

"We can store about one day's supplies on the actual site. Worst of all, there's only one entrance to the site – and to get to it you have to pass through the major roadworks we're doing just outside."

Colnbrook's secret is multiple dedicated production lines.

To keep the concrete flowing and the 3,000-plus workers on site busy, more than 100 vehicles an hour have to negotiate the cones and get into and out of the site during the restricted delivery hours. Each lorry has to turn up at the right work area at the right time with the right load. And when it gets there the site team has to be ready to roll.

"Construction has always been known for its low productivity compared to factory-based activities like car manufacture," Harper explains. "The main reason for that is unreliability – tackled effectively, pre-assembly is only a partial solution.

The T5 team's response began with the setting up of two 'logistic centres' – one just to the south of the site and one in Colnbrook – both within 5km of the entrance. Bulk materials – aggregates, cement, steel, shuttering and so on – are delivered to these by rail. Significant pre-assembly takes place there, with packages of materials and components delivered direct to the specified tower crane, as needed, by road.

But much more was needed to ensure that reliability increased significantly. "Just in time" delivery, a concept pioneered by the motor industry, can only be successfully applied if there is a cultural revolution within the project team.

"When we say this is a fully integrated team, we mean it," says structural engineer Connell Mott MacDonald divisional director Tim Dawson. "Detail design starts as late as possible to avoid delays caused by last minute changes. And the first thing we do is talk to the team which is actually going to build the section we're designing.

"This means the steelfixers have an input into the detail design, so buildability is the starting point," he adds.

A forest of 28 tower cranes dominates the T5 skyline.

Demanding work

At Colnbrook, BAA has invested £21M in a state of the art facility unlike any other in the UK. This is where the individual components of the 1M.m³ of reinforced concrete that T5 will need first come into proximity. Cement, PFA, aggregates and rebar arrive by train, to be marshalled, processed and delivered to site by road – but only when the site needs them.

"This is not a storage depot," emphasises T5 Laing O'Rourke operations manager Stuart Barr. "Everything is driven by the 'pull' from the work area on site. Material enters Colnbrook only when we know the site will need it within three days. The same applies to reinforcement production. Nothing starts until we have a call from

diameter they are very difficult to unroll on site," Barr adds. "So we roll an air hose in with the mat. On site this is pumped full of air, and air pressure alone neatly unrolls the mat."

Processed bar passes into six pre-assembly areas, where modular, reconfigurable jigs are served by four-strong cross-functional teams. Pre-assembled cages weighing up to 8t are welded together in

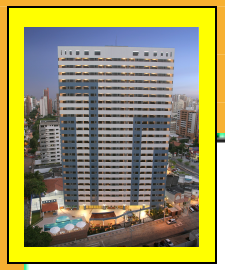
Results:

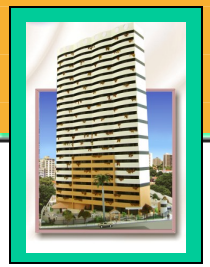
- First major UK civil project in last 40 years to be delivered on time
- $125 million cost savings in civils phase; 10% of contract value

KANBAN CARDS

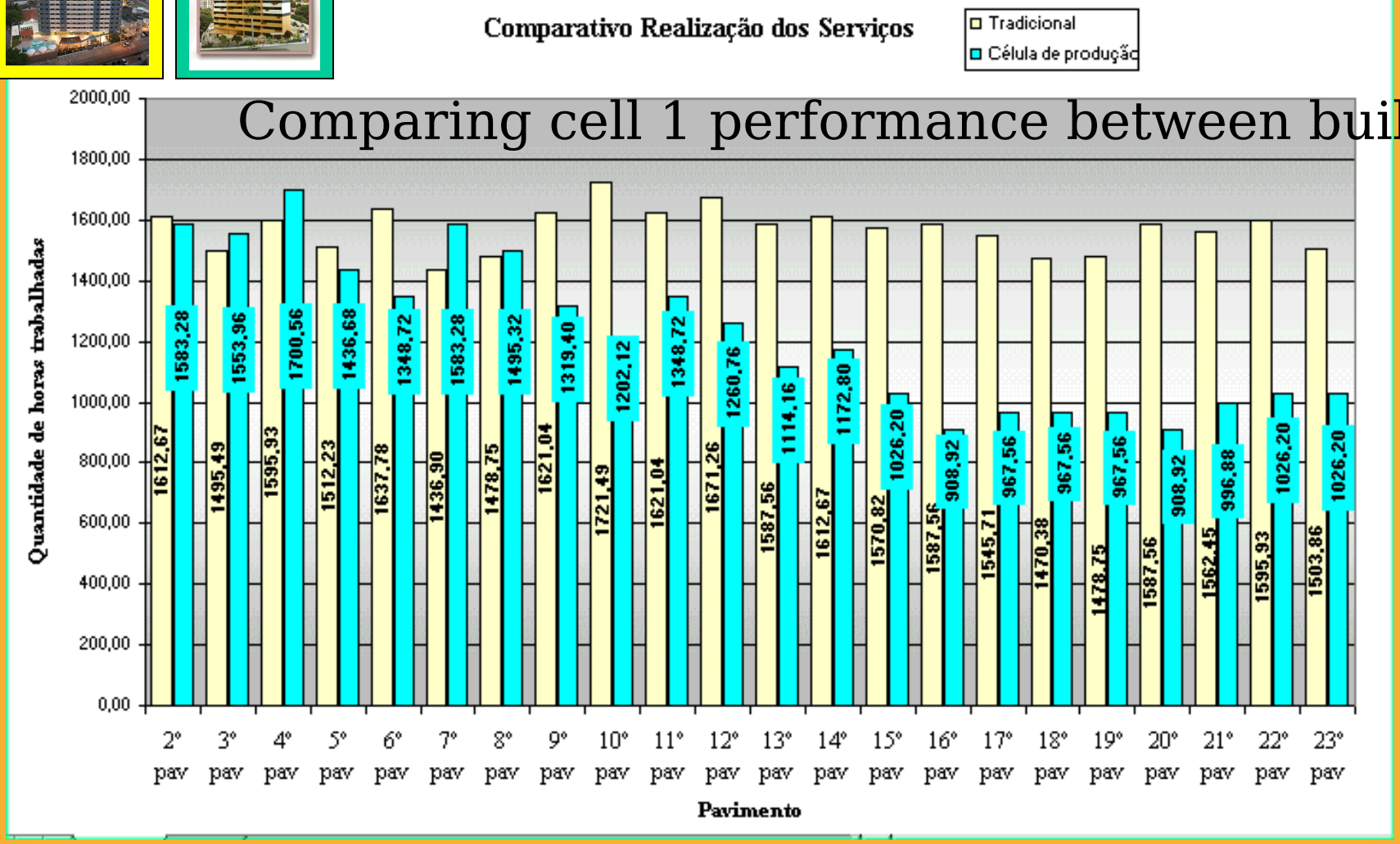
Quantities established to support standard production rates

Source: *Pedro Pereira, Fortaleza, Brasil*



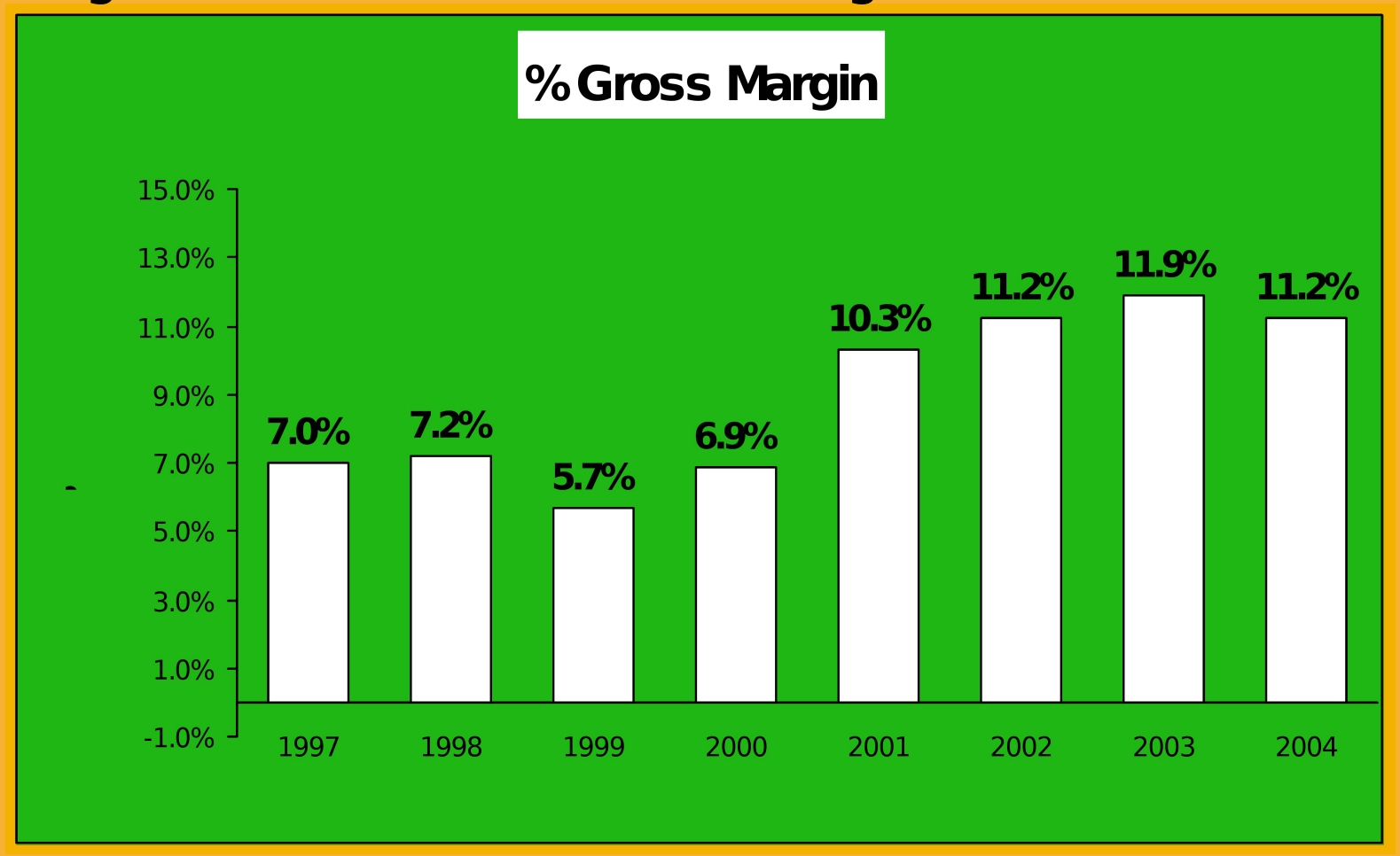


Comparing cell 1 performance between buildin



Source: *Pedro Pereira, Fortaleza, Brasil*

GyM Profitability Increase



Traditional versus Lean

- Decisions are made sequentially by specialists and ‘thrown over the wall’
- Product design is completed, then process design begins
- Not all product life cycle stages are considered in design
- Activities are performed as soon as possible

- Downstream players are involved in upstream decisions, and vice-versa
- Product and process are designed together
- All product life cycle stages are considered in design
- Activities are performed at the last responsible moment

Traditional versus Lean

- Separate organizations link together through the market, and take what the market offers
- Participants build up large inventories to protect their own interests
- Stakeholder interests are not aligned
- Learning occurs sporadically

- Systematic efforts are made to optimize supply chains
- Buffers are sized and located to perform their function of absorbing system variability
- Stakeholder interests are aligned
- Learning is incorporated into project, firm, and supply chain management

Making a Virtue of Necessity —aka Making Virtue Necessary

- ‘Lower the river to reveal the rocks’
  - Systematically stress the production system to identify needed improvements
  - Buffer the production system so experiments can be performed without risk of violating commercial agreements
- ‘Price – Profit = Cost
  - Artificially manipulate constraints to drive innovation and improvement

Target Costing vs Conventional Project Management

	St. Olaf College Fieldhouse	Carleton College Recreation Center
Completion Date	August 2002	April 2000
Project Duration	14 months	24 months
Gross Square Feet	114,000	85,414
Total Cost (incl. A/E & CM fees)	$11,716,836	$13,533,179
Cost per square foot	$102.79	$158.44

“If you always do what you always done, you’ll always get what you always got.”

Yogi Berra—baseball player and philosopher